

# MONTHLY WEATHER REVIEW.

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charge of the Jamaica Weather Office; Señor Anastasio Alfaro, Director of the National Observatory, San José, Costa Rica; Rev. L. Gangotiti, Director of the Meteorological Observatory of Belen College, Havana, Cuba.

As far as practicable the time of the seventy-fifth meridian, which is exactly five hours behind Greenwich time, is used in the text of the MONTHLY WEATHER REVIEW.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea level and latitude 45°.

## SPECIAL ARTICLES, NOTES, AND EXTRACTS.

### THE RELATION OF THE WEATHER TO THE FLOW OF STREAMS.

By F. H. BRANDENBURG, District Forecaster. Dated Denver, Colo., August 30, 1906.

The conditions, meteorological as well as physical, affecting run-off are so many and so varied that it is probable that every stream has its own law. While precipitation is, of course, the foundation of stream flow, other meteorological elements, such as temperature, wind, and dependent influences, greatly modify effects. These subordinate influences may work in unison or separately, and the extent of their influence, whether favorable or unfavorable, depends on the resultant of their departures.

The water in the streams may come either from surface run-off or from ground water. Whether the precipitation comes as rain or snow depends, of course, on the time of year as well as on altitude and exposure, and the geographical position of the watershed. For the great interior basin and adjacent regions the snowfall constitutes the main source of supply, since about sixty per cent or more of the annual amount falls during the six months, October to March.

For high altitudes thruout the west the year may naturally be divided into two periods—the period of storage, October to April, inclusive, and the period of run-off, May to September, inclusive. The principal meteorological conditions, and conditions resulting therefrom, affecting storage are: total fall, time of fall (that is whether early or late in the season), the condition of the ground, the prevailing temperature, and wind action. The time of fall controls to a large extent the character of the late flow. Snow that comes in the fall or early winter is subjected to occasional high temperatures as well as to prolonged periods of low temperature. In time it becomes solidified and practically ice, in which form melting in summer is relatively slow. Later snows, altho much wetter, are not subjected to such low temperatures, and as the period of storage is shorter the snow never becomes so hard packed. With the coming of a warm spell melting is rapid, and a correspondingly large run-off results. The condition of the ground, whether wet or dry, is important, for when the rainfall during all or a part of the warm half of the year is below normal, ground water will be correspondingly low; so that when melting takes place much of the moisture held in storage on the surface will go to make good the deficiency.

The condition of ground, whether frozen or unfrozen, affects the capacity of the ground to absorb moisture, and determines the proportion that appears as surface run-off, the unfrozen ground lessening the run-off during the early part of the season, and increasing the late flow by seepage.

Such high temperatures as occur during the storage period are not sufficient to cause a material melting at very high altitudes or in sheltered localities of less elevation. The effect of high afternoon temperatures is to cause the snow to settle, and as freezing weather prevails during the remainder of the twenty-four hours, solidification proceeds rapidly. Wind is a very important factor during the storage period. It is beneficial in packing the snow, and also in sweeping the snow into timber and other sheltered places. Wind, however, may become a detriment, as, for instance, when it partakes of the character of a chinook, or schnee fresser, as it is sometimes called from the fact that under its influence the snow disappears as by magic, leaving little or no visible moisture.

The period of run-off may be appropriately divided into two parts. The first and regular, as well as the more important, occurs in May and June, the time depending upon a joint effect on the one hand of the latitude and the elevation of the storage watershed, which are, of course, constant for a particular watershed; and on the other hand of the temperature, that is to say, whether the season is early or late, and whether days with abnormally high temperatures come in close succession, or whether there is a frequent alternation of short warm and cold spells. This early run-off is frequently due entirely to melting snow, and the amount of the flow depends on the extent and elevation of the area drained, as well as the depth and condition of the snow on the area. The late run-off will depend on the amount of the early and consequently solidified snowfall, the amount of ground water appearing as seepage, and the amount of rainfall. In many streams there is a secondary maximum due to rains; it generally occurs during the period of diminishing flow, and is common in the streams of the eastern and southern slopes. The rainfall of the interior basin in summer is generally too small to cause a second maximum. As compared with the run-off from melting snow, that furnished by rainfall is exceedingly variable in amount and time, and in general is much smaller. Owing to the occasional high intensity of local thunderstorms, a large pro-

portion of the water from such storms appears as surface flow, overflowing banks and causing damage in the vicinity of the storm area, but farther down stream it may be of decided help in increasing the available water supply.

As already noted, the rainfall in the great interior basin and thruout the northern Plateau is relatively small during the growing season, so that the run-off during late summer is supplied principally by ground waters, augmented somewhat by the melting of ice in sheltered spots at high altitude. On the southeastern slope, where the spring is almost rainless, the maximum run-off comes in May and the early part of June, but following the decline of the flow the rainy season sets in; sometimes it begins as early as July 1. Over many drainage areas of the eastern slope the amount of land under ditch is so great that the supply of water from melting snow becomes wholly inadequate in the latter part of the season, even when the snowfall of the preceding winter has been much in excess of the normal; for this reason the amount and distribution of the summer rains becomes a deciding factor.

Conditions that prevailed in Colorado several years ago furnish a good illustration of the principles enumerated. During the closing months of 1898 the snowfall along the Continental Divide and adjacent regions in Colorado was greater than had been experienced for many years. January, 1899, added 15 per cent and February a like amount, stormy weather being almost continuous, with plenty of wind to sweep the snow into the gulches and ravines. March, 1899, was even wetter than any of the four preceding months. As compared with the stupendous amounts that fell during that season, the next winter, that of 1899-1900, was dry, especially during January and March, tho October contributed a heavy fall, and February less than the normal amount for the region as a whole. It thus appears that the successive winters were notably different. The spring of 1899 was practically rainless, that of 1900 exceptionally wet. The summer of 1899 had slightly more than the normal precipitation, while the summer of 1900 was droughty. We now come to the water supply: the volume available on the eastern slope during the spring and summer of 1899 was inadequate, except for a brief period in June, notwithstanding the stupendous amount of snow that fell during the preceding winter. In 1900 irrigation enterprises fared better during spring and part of summer, despite the light snowfall of the preceding winter. The anomaly is explained by the fact that in consequence of the long, dry period which preceded the stormy winter of 1898-9, the ground was dry and unfrozen when the first snow fell, hence it absorbed a vast amount of moisture when melting began. The unusual dryness during spring played an important part, for, as is usual in droughty times, high winds, desiccating in character, were almost continuous, honeycombing the snow and causing a large proportion to disappear as if by magic. When the winter of 1899-1900 set in the ground was well supplied with moisture and frozen, as a rule, so that in the spring, which was notably free from high winds, the run-off reached the streams with comparatively little loss, and being augmented by seepage from the unprecedented fall of rain and melted snow during April (about ten inches) a most satisfactory flow was maintained until about the middle of July.

#### PHENOMENAL RAINFALL AT GUINEA, VA.

By E. A. EVANS, Section Director. Dated Richmond, Va., September 26, 1906.

On the 24th of August, 1906, there occurred at Guinea (P. O. Guineys), Caroline County, Va., a phenomenal fall of rain within a short period of time. Guinea is a station on the line of the Richmond, Fredericksburg, and Potomac Railroad [see *A* on the accompanying fig. 1], and the measured amount of rain of 9½ inches in about thirty minutes was made there by Mr. W. M. Jones, foreman in the roadway department of this railroad, and by him reported to the President, Judge Wm. J. Leake,

who subsequently placed the information in the hands of the writer. Mr. Jones is vouched for in the highest terms by his official superiors as a careful and accurate man, and has the confidence of all who know him.

Being much interested in establishing the facts regarding this enormous rainfall, I visited Guinea on September 3, and obtained the following information.

There were three measurements of rainfall made, one by Mr. Jones, in which instance the rain was caught in a tin bucket 9¼ inches deep and 8¾ inches in diameter, top and bottom. This bucket stood on a bench [*I*] in the yard and near the house [*B*] of Mr. Jones. The bench was 8 feet from the nearest part of the house and the bucket was about 20 inches above the ground. The exposure was such that only the rain falling from the sky could be caught. Mr. Jones states most positively that there was no water in the bucket before the rain set in.

The remaining two measurements were made [at *2* and *3*] by Mr. C. W. Tompkins, living about one mile north of Guinea. The first of these was taken from a wooden bucket 12 inches deep, 12 inches in diameter at the top, and 11 inches in diameter at the bottom, inside measure, and the last from two tin milk pails, 7½ inches deep and 11 inches in diameter, and 10 inches deep and 12 inches in diameter, respectively. These [two tin] pails had straight sides, were on the ground in an open pasture, and were placed one inside of the other.

The term "measurements" applies only indirectly, as there were no actual measurements taken at the time, the buckets being in each instance full and overflowing. The dimensions of the bucket at Mr. Jones's house were taken by the writer, while the dimensions of those at Mr. Tompkins's place were taken and reported by him. It is proper to say here that Mr. Tompkins is a man of standing in his community, and his responsibility is established and unquestioned.

Aside from the information furnished by Judge Wm. J. Leake, the details of this storm, as gathered by the writer, were obtained from various persons at Guinea, but chiefly from Messrs. Jones and Tompkins. They are as follows:

Weather before the storm very sultry, sky overcast, but not very threatening; thunder first heard about 4:30 p. m.; as the storm approached lightning became severe; rain began about 5:30 p. m.; about this time two heavy clouds met, one moving from the west, and the other from the northeast, and the rain immediately fell in torrents; according to Mr. Jones, corroborated by other witnesses, "it did not rain, but just poured down in solid sheets"; wind light; this condition lasted about thirty minutes, according to Mr. Jones—other eye witnesses make the time from five to ten minutes more—and then ceased, but light rain continued, ending about 6:30 p. m.; thunder last heard about 5 p. m.; the storm came from the west and moved almost due northward from Guinea; no rain of consequence fell 1½ miles east of Guinea.

Mr. Jones states that before the heavy rain ended he saw the railroad embankment, at a point marked *4* on fig. 1, beginning to wash away. He left his house to wire the railroad officials to hold trains, and passing by the bench on which the bucket first mentioned stood, he saw that it was full of water and running over. It continued raining very hard for some time afterward, according to his statement, and subsequently the second washout at the point marked *5*, on fig. 1, occurred.

After the rain, a work train was sent to the gravel bank at *D*, fig. 1, to get material to repair the embankment, but this track was under water and they could not get in. The washout had to be filled with cross ties, Mr. Jones stated.

Mr. Tompkins statement is as follows:

I was in my barn when the storm came up. It came from the direction of Guinea. Before I could get ready to leave the barn it was raining so hard that I was afraid to venture out. The storm lasted about forty-five minutes and after it was over I waded thru six inches of water on the level ground to get to my house [*C*]. In my yard on the north side of the house, but not adjacent to it, nor to any shed, was a wooden bucket [at *2*; the dimensions as previously given were taken subsequently at the request of the writer], which was full to the brim and running over. How much ran over I could not tell. I know the bucket was empty before the storm.